

# CFC Replacements: Minimizing the Environmental Risk

by Ann Botshon

It was not so very many years ago that the countries of the world recognized that the industrial chemicals known as chlorofluorocarbons (CFCs) are dangerously reducing the stratospheric ozone. In the landmark 1987 Montreal Protocol and subsequent agreements, nations consented to a phaseout of these useful but biosphere-threatening chemicals; in the United States, manufacture of CFCs ceases in January 1996.

That was the easy part. The hard part has been finding replacement substances that don't cause comparable environmental damage.

A case in point are the hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) now being used as CFC replacements in air conditioners, refrigerators, solvents, fire retardants and for other industrial processes. It is true that these second-generation compounds do not deplete the ozone layer; on the other hand, they do break down to another chemical, trifluoroacetic acid (TFA), whose behavior in the natural world now demands study.

TFA is highly water soluble, descending with the rain, snow etc., so the time it spends in the atmosphere is likely to be short. Manufacturers predicted that TFA would be "inert and benign" down here on Earth and asserted that although TFA would become widely distributed around the planet, it would cause no environmental problems.

But ecologists have begun to test in natural ecosystems the chemical companies' claim — microorganisms are known to break down compounds similar to TFA, which means that those chemicals, at least, are not inert. IES postdoctoral associate Sandy Tartowski has been working on the behavior of TFA within ecosystems of the Hubbard Brook Experimental Forest for the past two years, in collaboration with Institute director Dr. Gene E. Likens, the project's principal investigator, and fellow postdoctoral associate Dr. Torsten Berger. Colleagues at Syracuse University and Bayreuth University in Germany also collaborate in these studies. "We needed to study TFA's environmental fate, that is, its transport and transformation," explained Ms. Tartowski. Sufficiently concerned about the environmental fate of TFA, E.I. DuPont de Nemours & Co., Inc. is funding the research.

## Where TFA Might Be Found

To see where TFA goes, during the summer of 1994 the researchers sprayed TFA solutions on the surfaces of plots in two sites: a beech upland forest with dry, sandy soil, and a forested wetland with organic soil.

Ms. Tartowski and her colleagues found that in the beech forest most of the TFA remained dissolved in water and quickly percolated down through the sandy soil. In the rich organic wetland soils, however, results indicated that TFA did not percolate through with the water. "We suspect the TFA is sticking to the organic soils. We also think some of the TFA is going into plants," speculates Ms. Tartowski.

This year at Hubbard Brook Ms. Tartowski and project collaborators used radioactive TFA as a more sensitive way to detect the substance's transport and transformation. After spraying it on her test plots, she collected the gases given off by the system as well as the water percolating through. Her results suggest a pattern similar to that

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*Dr. Torsten Berger, a collaborator on the study of the environmental fate of TFA, takes a sample from a bulk precipitation collector at the Hubbard Brook Experimental Forest.*



## Newsletter

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### Director's Note

Human influence on ecosystem processes — whether immediate in the form of deposition of the by-products of industrial processes or remote in the form of changes in the land wrought by past generations — is an increasingly common element in our research. Industrial chemicals, with their obvious benefits and less obvious risks, are central to our research on TFA. Without the influx of European settlers, the stage would not have been set for the later introduction of gypsy moths and zebra mussels, nor would our landscape have been altered to allow for the complex relationships among deer, mice, Lyme disease and gypsy moth outbreaks.

The description of new research and updates on continuing research in this issue illustrate this common theme. Never has a single animal species had such a far-reaching impact on the Earth.

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# After the Zebra Mussel Invasion The Hudson River Has a New Look

by Ann Botshon

It was in the spring of 1991 that sturgeon fisherman and educator Jon Powell first discovered a zebra mussel in the waters of the Hudson River. By September 1992, only 17 months after its first sighting in the Hudson, the invading European mollusk had taken over the river so completely that its total weight was greater than the weight of all other river animals combined — it had become the river's dominant animal! And, with the spread of the pest, its principal food source, phytoplankton (mostly algae), had declined drastically, to less than 20 percent of pre-invasion levels.

Things looked unbelievably bad for the river in 1992, but from 1993 through 1995 Institute of Ecosystem Studies' scientists documented the zebra mussel's own (relative) decline from its population peak, its numbers falling each year to half of what they were the year before. The reason, according to IES freshwater ecologist Dr. David Strayer, is that young zebra mussel larvae are being produced but that relatively few are surviving. Why this is happening is not known for sure, but Dr. Strayer surmises that the adult mussels have taken so much food out of the system that little is left for their tiny offspring. Another possibility is cannibalism, with the adult mussels consuming their own larvae.

The decline of the mussel is by no means the end of the problem in the Hudson; Dr. Strayer sees the decline as a temporary one. "I think the most likely scenario is where the 'class of '92' peaks, then declines. As it falls, the algal population on which the mussels feed goes back up, providing enough food for the next class of larvae to

survive." Dr. Strayer foresees a cycling of mussel populations, with peaks every three to five years; as the years pass, he thinks, the peaks may become somewhat less pronounced.

## Impacts on the Food Web

Now that the zebra mussel is a fixture, the big question for Dr. Strayer and his IES colleagues is what happens to the river ecosystems. Institute biogeochemist Dr. Nina Caraco has generated a computer model of phytoplankton populations that has been useful in understanding how they respond to zebra mussels. "We'll never see the old Hudson River back," Dr. Strayer predicts. "In particular the summer algal bloom, key to so many river ecological relationships, is now a thing of the past."

In Lake Erie, when the invading zebra mussels consumed much of the phytoplankton, the water became clearer and more light could penetrate. This situation helped to stimulate phytoplankton growth and thus somewhat offset the effects of grazing. But unlike Lake Erie, the turbulence of the Hudson River keeps silt suspended so the water remains cloudy in spite of grazing. With light penetration only moderately increased, the river's phytoplankton populations have trouble rebounding from zebra mussel depredation.

Another big question is what will happen to the tiny riverine animals — the zooplankton — and the upper portions of the food web if the algae are gone. Some researchers predicted a major crash. But the best current evidence is that despite the mussels'

lightning spread and instant dominance, their impact has not reached far into the food web. Institute aquatic ecologist Dr. Michael Pace, who studies zooplankton and larval fish, has found that the small zooplankton have indeed disappeared, but the larger ones, such as crustaceans, have not. This suggests that zebra mussels are not competing with the crustaceans for food. Since the zebra mussels are eating the phytoplankton on which small crustaceans also feed, Dr. Pace thinks the crustaceans may have switched their diet and may now be surviving well enough on bacteria and bits of dead organic matter (detritus).

Preliminary fish monitoring data from New York's Department of Environmental Conservation and electric utilities also suggest that there have been no fish population crashes. (In Lake Erie as well, there has been no decline in such key species as yellow perch or walleye.)

Institute scientists are garnering valuable scientific information from the zebra mussel invasion. Dr. Strayer explains, "As unwanted as it is, the zebra mussel invasion enables us to ask basic questions about the ecosystem. We couldn't remove 85 percent of the algae experimentally to see what that would do to the ecosystem. But the zebra mussel has done it for us, giving us an unusual opportunity to see how the Hudson River works. The invasion is a disaster but we are getting useful information about how a major loss of phytoplankton affects the river's ecosystem, and how that compares with a similar loss in other water bodies, like Lake Erie."

Associate scientist Dr. David Strayer has been at the Institute of Ecosystem Studies since 1983, studying freshwater invertebrates. He is a principal investigator of a three-year National Science Foundation grant received this past summer, which will enable work on zebra mussels to continue. The other principal investigators on the project, and the part of the study on which they are focusing, are Drs. Nina Caraco (phytoplankton populations), Jonathan Cole (phytoplankton), Stuart Findlay (bacteria, sediments and detritus), and Michael Pace (zooplankton and larval fish). Much of the previous Institute work on zebra mussels was funded by the Hudson River Foundation.



Dr. Strayer holds the shell of a black sand shell clam, taken from a creek in western New York. These animals are among the many that are being affected by the presence of the zebra mussel.



## The Acorn Connection II: Fall 1995

Regular readers of the IES NEWSLETTER may recall a research program that began late in 1994, when IES ecologists Drs. Richard Ostfeld and Clive Jones saw that conditions were ideal for a project to learn about interrelationships among acorns, deer, white-footed mice, Lyme disease and gypsy moth outbreaks. ("The Acorn Connection": Vol. 11, No. 6: Nov. - Dec. 1994). 1994 was a mast year for oak trees in this region (a mast year is one in which acorn production is exceptionally high), with huge numbers of acorns falling to the forest floor. Acorns are a favorite food for deer and white-footed mice, both of which are hosts for the deer tick that transmits the Lyme disease bacterium, and white-footed mice are voracious predators of gypsy moth pupae. Drs. Ostfeld and Jones decided to introduce acorns to selected research plots during a poor mast year (which often follows a year of high acorn production) to learn what effects their abundance can have on an ecosystem.

In fall 1994 the scientists put out a public call for acorns. The response was overwhelming: 3,000 lbs of acorns were collected by over 80 local individuals. The acorns were transported by apple grower Steve Clarke to Conn Freezer Warehouses, Milton, N.Y. for cold storage. In fall 1995,



Mary Beth Scott and Deidre Dennis of Troop 451 were among the local scouts who helped to scatter acorns.

aided by local girl scouts from troops 40 and 451 and explorers from posts 31 and 32, IES scientists scattered these acorns and an additional 6,000 lbs they purchased — about 900,000 acorns in all — across research plots at the Institute. White-footed mice breed in the winter when acorns are available, so the expectation is that plots where acorns were added will have a larger population of mice than will those where no acorns were added. Deer tick and gypsy moth populations will be monitored during the coming field season, and results will be reported in the IES NEWSLETTER.

This research is part of the Institute's long-term study of Forest Responses to Stress and Damage (FORSTAD), supported by the General Reinsurance Corporation. When the company's assistant vice president, Mr. Richard Manz (below), visited IES in fall 1995, the scientists gave him a bag of acorns and the opportunity to help with some field work.



Enrollment in the Institute's Continuing Education Program currently tops 1,120, up 7% from the 1994-95 academic year. At a Certificate Recognition Ceremony held in the auditorium on November 16, graduates of the program, instructors and guests enjoyed a presentation by Mr. Rick Darke, curator of plants for Longwood Gardens, on "Gardened Landscapes Reverential to Regional Ecosystems", after which certificates were awarded.

Eleven students were recognized for completion of the requirements for a Certificate in Landscape Design, and 19 received a Certificate in Gardening. Here, Michelle Keeley receives her Certificate in Landscape Design from Institute Director Dr. Gene E. Likens. Looking on, l. to r., are Mr. William Montgomery, IES program leader for Continuing Education, and landscape design and gardening instructors Ms. E. Barrie Kavasch, Ms. Juliet Alsop Hubbard and Mr. Art Elmers.

## CFC Replacements, from page 1

found the previous year. "I think it's likely that TFA is mainly transported in water, but that there is a lot of diversity in the landscape and the compound can be concentrated in wetlands and possibly other systems."

### Will TFA Become Something Else?

With increasing global dependence on chemicals, there are instances in which the negative consequences of these compounds have not been discovered until long after their use has become widespread. Dr. Likens and collaborator Dr. Charles Driscoll (Syracuse University) had serious scientific questions about what happens to TFA over time. The funding from DuPont is allowing them and their colleagues to determine if there are any potentially

detrimental environmental effects resulting from the breakdown of this compound.

"You would think that TFA breakdown would be easy to determine in the laboratory," Ms. Tartowski says, "but it hasn't been." Some experiments have indicated that microorganisms do break down TFA under a variety of chemical conditions, but results, even from the same lab, have not been consistent. "The laboratory microbiology has been inconclusive, and we still don't know if TFA breakdown is important in the field. It may be that the compound's breakdown is slow but, over a long time, ecologically significant."

The scientists currently are preparing the results of their studies for publication.

Sandy Tartowski will receive her Ph.D. from Cornell University for work on nitrogen dynamics in semiarid grazing systems in Australia. She returned to the U.S. about four years ago and joined the Institute staff in 1994.

Torsten W. Berger (pictured on page 1) received his Ph.D. from Universität Bodenkultur in Vienna, Austria for investigations on oak decline, focusing on nutrient budgets of Austrian oak forests with special regard to deposition of atmospheric pollutants. He received an Austrian Erwin Schrödinger Fellowship for his two-year postdoctoral research position at IES, and in September 1996 will return to his research position at Universität Bodenkultur.



## Calendar

### CONTINUING EDUCATION

For Winter/Spring semester catalogues and program information, call the Continuing Education office at 914/677-9643. Late winter semester programs include:

#### *Landscape Design*

Mar. 10: Landscape Design with Native Herbs Gardening

Mar. 7 (to 4/18): Floriculture

Mar. 9: Water Lilies and Other Aquatic Plants

Mar. 16: Basic Cultural Techniques for Perennials

Mar. 23: Pruning Trees and Shrubs

Mar. 30: Understanding Botanical and Horticultural Names

#### *Workshops*

Mar. 3: Wildflower Celebration

Mar. 23: Careers in Landscape Design

Mar. 30: Wetlands: Ecology, Creation and Restoration

#### *Other Courses*

Mar. 9 & 16: Intermediate Flower Arranging Excursions and Tours

Mar. 11: New York Flower Show

Mar. 28: Greater New York Orchid Show

### SUNDAY ECOLOGY PROGRAMS

Free public programs are held on the first and third Sunday of the month, except over holiday weekends. Call 914/677-5359 to confirm the day's topic or, in case of poor weather, to learn the status of the day's program. The following programs begin at 2 p.m. at the Gifford House: Mar. 3: Human Accelerated Environmental Change, slide presentation by Dr. Gene E. Likens  
Mar. 17: A Catskill Conundrum, slide presentation by Dr. Kathleen Weathers

### IES SEMINARS

Free scientific seminars are held each Friday at 3:30 p.m. at the IES Auditorium:  
Feb. 29 (Thursday): Linkage Between Science and Policy. Speaker: IES Visiting Distinguished Scientist Dr. Deborah B. Jensen, The Nature Conservancy, Arlington, Va.

### Seminars, continued:

Mar. 1: Climate Change and Northern Prairie Wetlands: Simulations of Long-term Dynamics. Speaker: Dr. Karen Poiani, The Nature Conservancy, Minneapolis, Minn.

Mar. 8: Topic: Ecologists and environmental issues. Speaker: Dr. Sara F. Tjossem, U. of Minn.

Mar. 15: Scientific Studies for the Protection of the New York City Water Supply. Speaker: Dr. Lorraine Janus, N.Y.C. Dept. of Environmental Conservation

Mar. 22: Topic: Use of solute transport experiments and models. Speaker: Dr. Susan Hendricks, Murray State Univ., Kentucky

Mar. 29: Effects of Epiphyte Communities on Tropical Cloud Forest Nutrient Cycles: A Decade of Canopy Research in Monteverde, Costa Rica. Speaker: Dr. Nalini M. Nadkarni, Evergreen State College, Washington

### VOLUNTEER OPPORTUNITIES

Volunteers currently are needed for projects relating to the IES display gardens: plant research, pruning, seed collecting, data entry, spring clean-up. For information on responsibilities and benefits, call Ms. Su Marcy at 914/677-5359.

### GREENHOUSE

The IES greenhouse, a year-round tropical plant paradise and a site for controlled environmental research, is open until 4:00 p.m. daily except public holidays. Admission is by free permit\*.

### HOURS

Winter hours: October 1 - April 30

Closed on public holidays.

Roadways are closed when snow-covered.

Public attractions are open Mon. - Sat., 9 a.m. - 4 p.m. & Sun. 1 - 4 p.m., with a free permit\*.

The IES Gift and Plant Shop is open Mon.- Sat., 11 a.m. - 4 p.m. & Sun. 1 - 4 p.m. (The shop is closed weekdays from 1 - 1:30 p.m.)

\* Free permits are required for visitors and are available at the Gift Shop daily until 3 p.m.

### IES GIFT AND PLANT SHOP

New in the Shop ... "Schroeder Designs": original earrings by the IES perennial gardener ... books about local and regional hiking trails ... for children ... "Garden/Science Wizardry for Kids", books and kits ... and in the Plant Shop ... "Toadstools": plant fertilizer garden ornaments ... Senior Citizens Days: 10% off on Wednesdays  
\*\* Gift Certificates are available \*\*

### MEMBERSHIP

Join the Institute of Ecosystem Studies. Benefits include a member's rate for courses & excursions, a 10% discount on Gift Shop purchases, a free subscription to the newsletter and participation in a reciprocal admissions program. Individual membership: \$30; family membership: \$40. Call Ms. Janice Claiborne at 914/677-5343.

#### **The Institute's Aldo Leopold Society**

In addition to receiving the benefits listed above, members of The Aldo Leopold Society are invited guests at spring and fall IES science updates. Call Ms. Jan Mittan at 914/677-5343.

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